NATURAL GAS LIQUIDS

— An Overview For Ontario —

June, 1985

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The information appearing in this document was compiled in August 1984.

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1. INTRODUCTION

As energy prices soared in the 1970's, efforts were made to reduce Canada's dependence on imported crude oil. As part of the search for crude oil substitutes, Natural Gas Liquids (NGL's) were examined. Natural Gas Liquids include the hydrocarbon compounds ethane, propane, butane, and pentanes plus. All of these compounds are derived from natural gas, of which there are large domestic reserves. Propane and butane are also produced as by-products of the crude oil refining process.

Natural Gas Liquids are used throughout Canada for a wide range of purposes. Large volumes of butane are used in gasoline blending, and recently, propane's use as a gasoline substitute in automobiles has grown. Propane is also used as an alternative to fuel oil for uses such as home heating and crop drying.

Natural Gas Liquids are used in the petrochemical industry as a substitute for crude oil based feedstocks. These hydrocarbons are also injected into crude oil reservoirs to enhance oil recovery. Pentanes plus are used to aid in the pipeline movement of crude/bitumen supplies and concentrated NGL streams.

Most of Canada's NGL supplies are concentrated in Alberta's natural gas reserves. As outlined above, these supplies compete for a wide range of markets throughout the country. Therefore, any consideration of NGL use in Ontario cannot be separated from the Canadian NGL supply/demand situation.

Since no comprehensive evaluation of NGL's had been done to date, this document was prepared to serve as an overview of all aspects of natural gas liquids. This paper discusses NGL pricing, examines the supply situation, and looks at the range of uses for each natural gas liquid. Finally, it outlines what the supply/demand situation is likely to be in the future and summarizes the potential for use of each natural gas liquid in Ontario.

2. AN OVERVIEW

The majority of Canada's conventional energy supplies are based on hydrocarbons — compounds composed of the elements hydrogen (H) and carbon (C). Hydrocarbons may be gaseous, liquid, or solid at normal temperature and pressure (STP), depending on the number and arrangement of the carbon atoms in their molecules. Compounds with up to four carbon atoms are gaseous while compounds with between five and twenty carbon atoms are liquid (Figure 2.1).

Sources of Gas Liquids

Two common sources of hydrocarbons are crude oil and raw natural gas. During the processing of raw natural gas, compounds known as Natural Gas Liquids (NGL's) are often recovered. These hydrocarbons, commonly found in association with methane (CH_4), the principal component of natural gas, include the odourless, colourless, hydrocarbon gases ethane, propane and butane as well as liquids known as pentanes plus.

Propane and butanes, also known as Liquid Petroleum Gases (LPG's), can be recovered from crude oil as well. A barrel of crude oil can be separated into a large number of hydrocarbon compounds. During the distillation of crude oil and during the various processes which separate the crude oil fractions, propane and butane gases can be recovered.

Figure 2.1

Hydrocarbon Classification

Classification		**Compound**	**State (@ Standard Temperature and Pressure)**
Natural Gas		Methane (CH_4)	Gas
NGL's		Ethane (C_2H_6)	Gas
NGL's	LPG'S	Propane (C_3H_8)	Gas
NGL's	LPG'S	Butane (C_4H_{10})	Gas
NGL's		Pentanes Plus (C_5H_{12} and higher)	Liquid

NGL Supply

Canada has large amounts of gas liquids with total established reserves estimated to be 202,777 x $10^3 m^3$ as of the end of 1983 (4, p.9). These natural gas liquids are important to Canada's economy with output in 1983 valued at near $2.2 billion (21, p.14).

Historically, the majority of Canada's NGL production has been tied to natural gas and crude oil production based in Alberta. In 1983, all of Canada's pentanes plus and ethane supplies as well as 80 per cent of Canada's propane and 75 per cent of Canada's butane supplies were stripped from unprocessed natural gas obtained from Alberta.

Ontario has low crude oil production and Ontario's relatively small natural gas reserves contain only minor amounts of NGL's. Therefore, virtually all NGL's used in Ontario originate in Alberta. About 10 per cent of Ontario's NGL supply is obtained by the refining of crude oil (20, p.54; 13, p.IV-2). The remaining volumes are transported as liquids through the InterProvincial Pipeline system from Alberta to gas fractionation facilities in Sarnia. Here the various hydrocarbon components are separated and distributed for use throughout Ontario.

Domestic NGL Consumption

There are a wide range of markets available for Natural Gas Liquids in Canada (Figure 2.2). Since the value of NGL's for these markets is presently quite high, most available gas liquids are extracted from raw natural gas and crude oil.

A major use of NGL's in Canada is as a miscible flood. Light hydrocarbons are injected into oil wells to induce recovery of a higher percentage of crude oil reserves. Most miscible flood projects use a high proportion of propane in the solvent mix and the use of ethane for miscible flood purposes is projected to increase. In the future, up to 50 per cent of the liquids used in miscible flood projects will likely be recovered.

Very little pentanes plus are contained in the NGL mix that is injected as a solvent. Most pentanes plus are used as diluent to enable heavy crude oil to flow through pipelines. Other uses of pentanes plus such as petrochemical and NGL transport uses are decreasing as diluent requirements increase.

Propane and butane are the most widely used gas liquids at the consumer level. They can be maintained in a liquid state at room temperature at just over atmospheric pressure and can therefore be safely marketed in steel containers. By combining the clean, even heat of natural gas with the portability of oil, these fuels are suitable for a wide range of uses.

Because of the alternative markets available to propane, its price is highly sensitive to fuel prices. Since at present propane is competitively priced relative to oil and electricity, where natural gas in unavailable propane is frequently used for heating, cooking, and crop drying. Propane's portability has resulted in its use for metal-cutting torches and to power fork lift trucks. The use of propane for vehicle carburation is growing as the result of the economics of propane for high mileage, urban driven vehicles, and due to government incentives.

Propane and other NGL's are also used as a petrochemical feedstock. Crude oil, natural gas, or natural gas liquids can be used as the raw material (feedstock) from which organic chemicals (petrochemicals) such as ethylene are produced. The decision on which feedstock to use is partially determined by refinery capabilities. In Eastern Canada, the major ethylene producers use crude oil derivatives — naphtha, gas oil, and condensate — as raw materials. These plants can be converted, with some capital investment, to run on various NGL's. In Western Canada, the petrochemical facilities were constructed to use ethane to produce ethylene. These facilities could not be easily adapted to use other feedstocks.

Ontario's petrochemical producers must consider the demand for petrochemical co-products when deciding on which feedstock to use. When oil-based feedstocks are used, large quantities of co-products such as propylene and butadiene are produced. These co-products are subsequently upgraded and used to manufacture a wide range of petrochemical products including synthetic rubbers, plastic resins, paints, and synthetic textiles. When petrochemical producers consider NGL's, they must examine differing co-product yields. Pentanes plus produce large volumes of butadiene; butane produces lower volumes and propane even less. Ethane cracking results in the production of insignificant amounts of butadiene and propylene but give the highest yields of ethylene with yields reaching 75-80 per cent (3, p.381). With Ontario's continued need for petrochemical co-products, it is unlikely that ethane will become the major petrochemical feedstock.

The final factors influencing feedstock choice are availability and price. Pentanes plus are in limited supply and therefore have little potential for increased petrochemical use. However, there are domestically produced surpluses of ethane, propane and butane. In contrast, Canada is still a net importer of crude oil. While oil prices in Canada used to be approximately 85% of world price, they have recently risen near to world levels. As a result of this loss of advantage in feedstock prices over competing U.S. petrochemical producers, Ontario's petrochemical industry is considering converting some of its facilities to accept a wider range of feedstocks, including propane and butane.

Increased petrochemical use of NGL's is dependent on whether the industry is able to obtain assured supplies of low cost propane and butane. At present, butane has a high market value for use in gasoline blending and, since more butane is required to make an equivalent amount of ethylene, is therefore generally not competitive for petrochemical use. This means that propane is the most attractive NGL for use as a feedstock in Ontario's petrochemical industry.

Natural Gas Liquids Exports

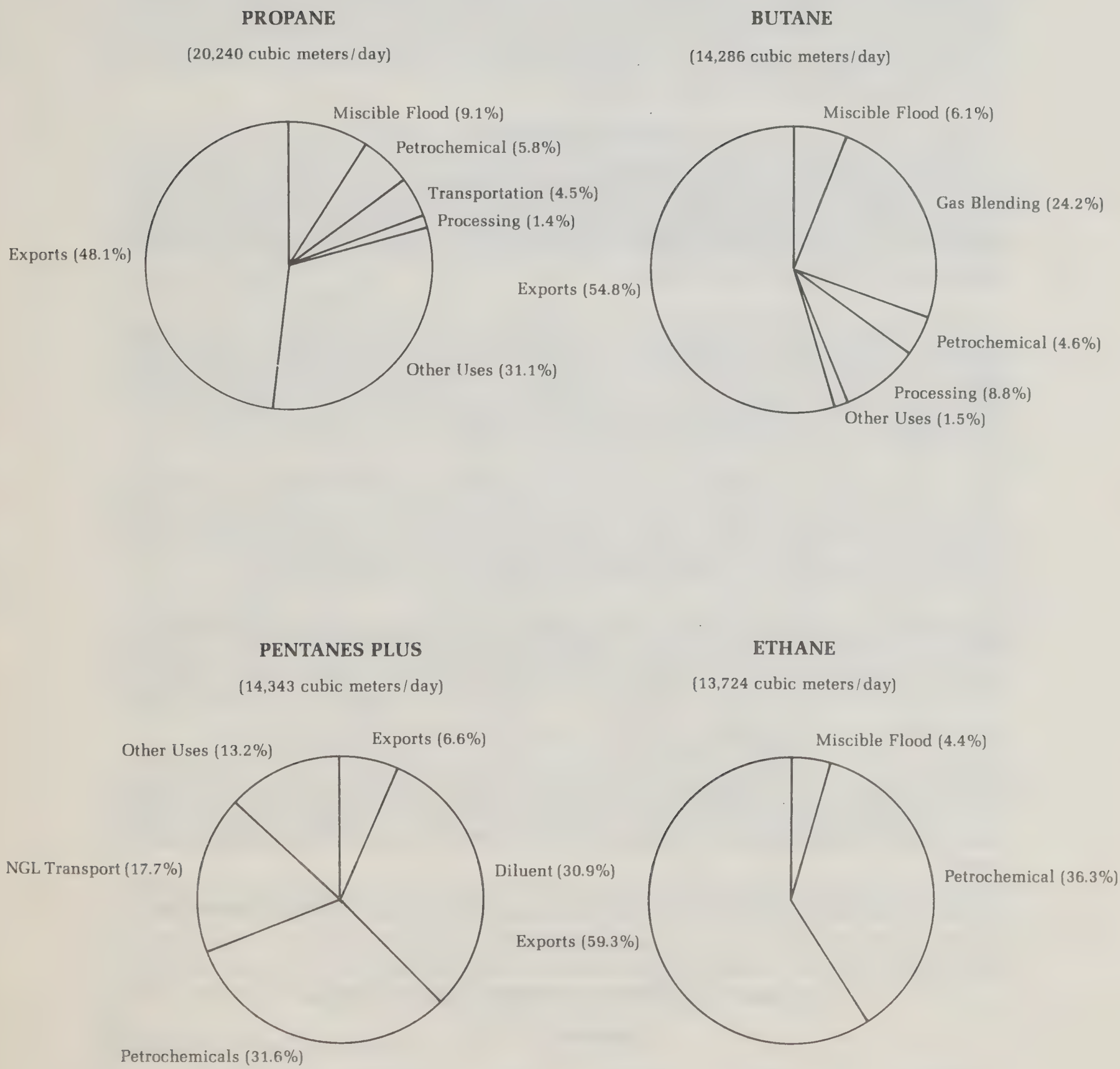
Whatever NGL's are not used in Canada can be extracted and exported to the United States and other countries. Exports of ethane have increased as foreign demand for ethane for use in ethylene production have grown. Exports of segregated pentanes plus are decreasing as it is in limited supply and there is a large domestic demand for pentanes plus as a diluent.

Production of propane and butanes is in excess of domestic demand and this surplus had traditionally been exported to the United States and Japan. In the future there could be increased competition for those export markets. Recently OPEC countries began to separate out gas liquids, something they did not do in the past. As a result, between 1983 and 1995, worldwide supplies of propane and butane could grow by 41% to 132 million metric tonnes/year (34, p.5). At the same time world demand is expected to grow only 27%, leaving a surplus of some 13.5 million tonnes/year. This surplus could result in decreased foreign demand for Canada's surplus gas liquids.

Figure 2.2

NGL Consumption in Canada

(1983)



Source: "Propane in Canada", Dome Petroleum Ltd., 1984

3. PROPANE

Propane Supply

Factors affecting supply include how much oil is refined in Canada, what balance is struck among refinery products, the amount of natural gas produced in Canada, and how "wet" the gas is. Historically, propane production has been impaired whenever poor markets have lowered natural gas production. In the future, natural gas "cycling" may reduce this problem. Cycling allows gas to be produced from a reservoir, its liquid components stripped from it, and the remaining gas reinjected into the well (2, p.11).

While cycling technology allows propane to be removed from natural gas even if the gas is not sold, natural gas contains differing amounts of NGL's depending on its source. In general, only 15% of the propane from natural gas streams must be removed to "dry" the gas enough to prevent condensation during pipeline transport (25, p.3). Most propane can be left in the natural gas stream and only be taken out if the price is right.

In recent years most of the NGL's have been removed from Alberta's natural gas streams. Natural Gas production from existing connected pools is expected to become increasingly dry (27, p.2). Therefore, in spite of projected increases in natural gas sales, propane and other natural gas liquid yields will remain at approximately the same levels over time (27, p.2).

Domestic propane supplies presently exceed demand. This surplus will likely increase in the mid-1980's and then fall slightly towards the end of the 1990's (29, p.44). As domestic propane use increases, exports could be reduced and/or a higher percentage of propane could be removed from natural gas.

Historically, natural gas processing plants have accounted for approximately 80% of Canadian propane supply. Between 1979 and 1983 gas plant production was approximately 16,000 m^3/d as compared to refinery production which was near 4,000 m^3/d (Table 3.1). Production of propane from gas plants is expected to increase to the mid-1980's and then level off through 1990 (20, p.13).

About two percent of the crude oil input to an oil refinery is recoverable as propane (25, p.7). Future crude oil refinery production is expected to be fairly stable, declining slightly by the end of the 1980's due to lower crude runs (29, p.44).

Table 3.1

Historical Propane Supply in Canada

(thousand m^3/d)

Supply	**1979**	**1980**	**1981**	**1982**	**1983** (est.)
Gas Plants	16.9	16.2	15.8	15.8	15.2
Refineries	3.5	3.8	3.7	3.2	3.5
TOTAL	20.4	20.0	19.5	19.0	18.7

(Source: NEB, CANADIAN ENERGY: Supply and Demand 1983-2005)

In the short term, a world wide surplus of propane is expected as foreign crude oil suppliers may insist that buyers take some propane to qualify for crude oil purchases (31, p.83). New domestic sources of propane may come onstream in the medium term. Propane can be produced by synthetic crude oil plants and from frontier areas (especially the Mackenzie Delta and the Scotia Shelf). These sources may provide significant volumes of propane by the late 1990's (20, p.3).

Propane production is expected to increase slightly throughout the 1980's to over 22,000 m^3/day by 1990. This increase will be due to strong growth in demand for propane as an engine fuel, increased use of propane to enhance oil recovery, and to a lesser extent increased use as a petrochemical feedstock (2, p.11).

Propane Prices

The volume of propane extracted from natural gas and crude oil is directly related to the price of propane. A greater percentage of total available propane is removed as propane price increases making extraction increasingly economical.

Pricing Influences

The price of propane in Canada is not regulated (except in Nova Scotia) and is determined by the marketplace. There are three primary pricing influences. First, the major factor influencing Canadian propane prices is the U.S. market. Volumes of propane not required for domestic purposes are exported to the United States. With more Canadian propane being sold in the U.S. than in Canada, U.S. market forces tend to dominate our pricing.

Allowable export volumes and a minimum export price are set and reviewed monthly by the National Energy Board to ensure that Alberta propane remains competitive in northern U.S. markets (25, p.17). Canadian suppliers do not charge higher prices in Canada than they realize by exportation in order to avoid charges of "dumping" products into the U.S. market (1, p.11). As a result, volatile propane prices in the United States have at times served to hold down the price for propane in Canada (5, p.2).

Second, during some periods in which export prices have increased, domestic prices have been constrained by competition with fuel oil prices (26). Since the principal use of propane is as a heating fuel, producers must attempt to keep the price of propane near to the price of fuel oil, its main competitor.

Third, since propane is produced mainly from natural gas, the price of propane is related to the selling price of natural gas. As an extract, propane's price is expected to remain above that of natural gas. If demand for propane were to fall resulting in a low selling price, propane could always be left in the natural gas stream and be sold at the methane price.

Ontario Retail Prices

The wholesale price for domestic propane in Alberta is generally near the propane export price or the domestic crude oil price, whichever is lowest. Retail prices in Ontario are generally set according to the wholesale price for domestic propane in Alberta plus the cost of transportation to Ontario distribution costs within Ontario and a certain profit margin (Fig. 3.1). This profit margin is determined by market influences. While dealers can make a profit when there is high demand for propane, they may be forced to take a loss if demand drops in order to retain their share of the market.

The retail price of propane within the province can vary up to 30% between end-use sectors (20, p.14). This price difference partly reflects differences in the cost of distributing propane to customers. Prices vary depending on the customers' location, the quantity of propane purchased, the mode of delivery, and the prices of alternative fuels available on local markets.

Future Pricing Trends

Increasing world propane supplies and decreasing domestic surplus available for export is expected to gradually lessen the influence of U.S. markets on Canadian propane prices. This may induce domestic prices to remain below export prices. However, this is not expected to happen for several years (12, p.111-13). Therefore, the U.S. propane-to-crude oil price ratios are considered to be the most significant factor in determining Canadian propane prices for at least the next several years.

In the short term, propane will likely maintain its present price relationship with crude oil and natural gas (31, p.78). On a liquid volume basis, the price of propane in Alberta is forecast to remain at 85% of the price of light fuel oil in Sarnia (Ministry of Energy) on a heat content basis. However, if propane continues to compete less with fuel oil in the residential space heating market and more with gasoline in the transportation sector, the wholesale price for propane may eventually rise above the domestic crude oil price, although the two would still be related (20, p.5).

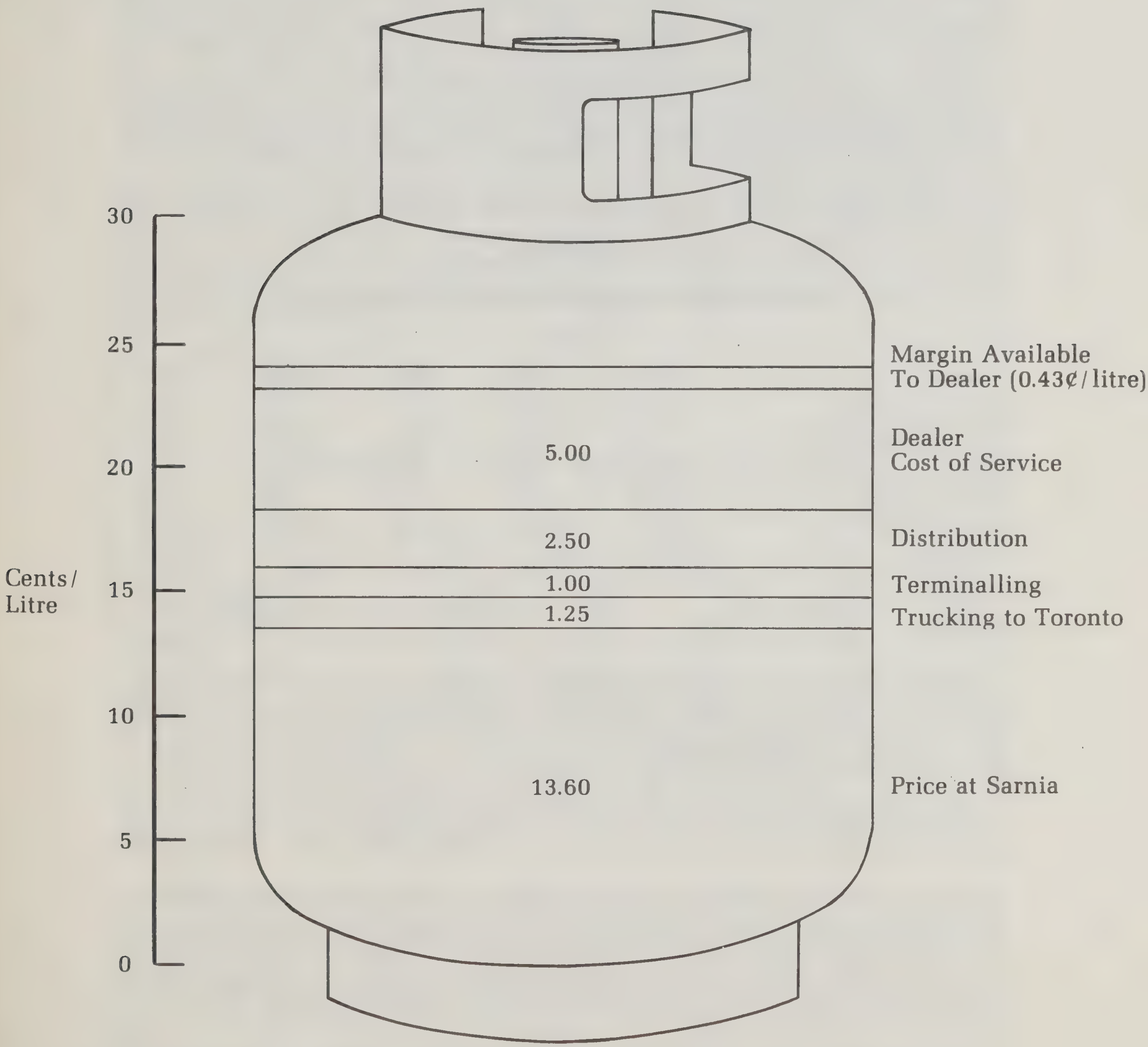
Since 1975 the price of propane has risen about nine per cent per annum (20, p.11). The present forecast is for propane prices in Canada to experience an annual growth rate of near 7% into the 1990's (11, p.111-5).

In general, price influences demand. If propane prices drop significantly below competitive fuels, demand is expected to increase, and vice-versa. While long term price changes appear to influence propane demand for most uses, there is some debate over the sensitivity of propane as a motor fuel to price. Significant penetration of propane into automotive fuel markets may be related more to government grants and tax incentives than to lower comparative prices (6, p.VI-5).

Figure 3.1

Breakdown of Propane Pump Price

(June 1985 in Toronto @ 23.78¢/litre)



(Source: Dome Petroleum Limited, 1985 — reference #26)

Canada's Use of Propane

Domestic propane consumption is closely linked to the price of propane as compared to alternative fuels. While propane consumption for various uses changes with the price of propane, propane is used for a wide range of applications (Table 3.2). In western provinces propane is injected into oil wells to enhance crude oil recovery. Throughout Canada propane provides convenient energy in rural communities for domestic uses such as cooking, water heating, space heating, and refrigeration and for farm applications such as crop drying, brooder heating and milk processing. Propane prices that are highly competitive with furnace oil in Alberta are progressively less so as distance and transportation costs from Alberta increase. Propane has commercial uses in restaurants, schools, and hospitals. Industrial uses of propane include the powering of fork lift trucks and the fueling of soldering tools. Propane is also used throughout Canada as a transportation fuel and it is used in the production of petrochemical products. In addition, some propane is lost during processing, is not recovered, or is used as energy for crude oil refining.

Table 3.2

Historical Propane Demand in Canada

(m^3/d)

Demand	1979	1980	1981	1982	1983
Miscible Flood	1,556	1,427	1,374	1,366	1,835
Transportation*	75	100	125	560	910
Petrochemical	1,084	983	784	681	1,165
Processing	676	352	305	450	284
All Other Uses	6,481	6,584	6,427	6,880	6,306
TOTAL	9,872	9,446	9,015	9,937	10,500

*Dome Petroleum Estimate (Source: NEB, Product Disposition Summary Reports)

Canadian propane demand in the residential and commercial sectors is expected to remain fairly static. The major area for growth in domestic propane sales is as an automotive engine fuel (29, p.44). As a result of the removal of Ontario's Road Tax on automotive propane sales, propane sold as automotive engine fuel is priced cheaper than propane for home heating which must also include delivery costs (17). As a result, propane provides most savings when compared to gasoline for transportation use.

Allowing for energy efficiency, fuel savings can range up to 30% of the total fuel bill. This saving in combination with government incentives, is expected to make transportation the major growth market for propane consumption. A study by Canadian Resourcecon Ltd. estimated propane use based on two levels of penetration into Canada's commercial gasoline market:

Potential Propane Penetration of Commercial Gasoline Market

(m^3/d)

MARKET SHARE	Western	Central	Maritimes	Total Canada
10%	1034	1637	286	2956
25%	2574	4116	731	7421

(Source: 32, p.18)

Growth in the propane carburation market will not place a large demand on propane shipments. Propane demand is seasonal, with sales during the winter months being roughly triple those during summer months (20, p.53). However, since propane use for vehicles peaks in the summer months, increased propane carburation will tend to even out the seasonality of propane demand.

It appears that all projected propane demand will be supplied from domestic sources. Overall, domestic propane demand is expected to increase into the late 1980's and then stabilize over the longer period (6, p.VI-5).

Ontario's Use Of Propane

In 1983, approximately 67 per cent of the propane entering Ontario went to domestic markets with the remainder being exported to the United States. The petrochemical industry consumed 31 per cent of this domestic use, transportation accounted for 18 per cent, and the remaining 51 per cent went for other domestic uses (Table 3.3). Propane petrochemical use is expected to increase slightly before 1990 and again modestly after the turn of the century (6, p.VI-5). Residential, agricultural, and commercial uses are expected to remain fairly constant in the future.

Table 3.3

Historical Propane Demand in Ontario

(m^3/d)

Demand	1979	1980	1981	1982	1983
Transportation*	10	48	60	372	605
Petrochemical	1,030	787	650	589	1,075
Industry	413	168	98	206	89
All Other Uses	1,560	1,537	1,613	1,683	1,661
TOTAL	3,013	2,540	2,421	2,850	3,430

* Dome Petroleum Estimate

(Source: NEB, Product Disposition Summary Reports)

Residential and Commercial

Traditionally, outside Alberta the major market for propane has been for space heating (5, p.4). In locations where natural gas is unavailable and propane is less expensive than oil and electricity, propane is often selected to fuel furnaces and appliances. It burns evenly and has a heating value of about two and a half times that of the same volume of natural gas (25, p.10). It can also be used for hot water heaters, cooking stoves, and clothes dryers. But its use for these purposes is usually limited to buildings where it is also used for space heating.

The total cost of converting the space heating requirements of a residence to propane was estimated in 1980 to be $800 (31, p.69). The estimated conversion costs for an existing oil fired hot water heater was about $200 in 1980 (31, p.70). Most propane suppliers provide and install the necessary storage tanks and equipment and rent them to the customer on a monthly basis.

Propane is also widely used where a portable fuel source is desirable. Applications include its use in barbecues and camping trailers. The use of propane as a portable fuel will likely increase in the future as recreational uses grow in popularity.

The use of propane for home heating is dependent on the price of alternative fuels. In areas where natural gas is not available there may be conversion from oil to propane, electricity or wood.

Between 1979 and 1983 propane use in the residential sector approximately doubled (30). However, as most economic conversions to propane have already taken place with the recently concluded Canada Oil Substitution Program (COSP) grants, future demand for propane as a heating fuel is not likely to significantly increase. While propane has become increasingly competitive with light fuel oil (26), in most major centers propane is still more expensive when heating efficiencies are taken into account (17). As conservation measures are implemented, propane demand for home heating may decline at a rate of up to two percent per year (20, p.27).

Agricultural

In the agricultural sector, propane is used principally for crop drying, especially tobacco and corn, and for poultry brooder heating. Natural gas, which could be used for these purposes, is often unavailable on farms and electricity is too costly for such applications. Oil does not burn cleanly and therefore is dangerous to chickens and may contaminate the crops being dried.

Drying crops prior to storage prevents spoilage that might otherwise take place if the crop was wet or even damp when stored. Many farmers depend on propane for drying crops because it provides quick, controllable heat at the necessary constant temperature and does not leave any objectionable residues. While commercial driers are often located in towns where natural gas is available, most driers located on farms in Ontario use propane as a fuel (35, p.14).
a fuel (35, p.14).

Drying times and the amount of propane used depend on the type of crop being dried and the weather. For instance, tobacco, grown mainly in Southwestern Ontario, requires curing in the kilns for an eight day period at a temperature which begins at 35°C, and gradually climbs to 74°C.

In 1983, agricultural use amounted to 9% of total distributor sales of propane in Ontario (30). Different uses account for approximately the following proportions of the total amount of propane used for agricultural purposes:

	Use	Market Share	Seasonality
Crop Drying -	Tobacco	30%	July - August
	Beans, Wheat	10%	August - Sept.
	Corn	30%	Oct. - Dec.
Brooder Heating		30%	Winter peak

(Source: 31, p.15)

Agricultural use of propane peaks in late fall/early winter and is lowest in the spring. But because agricultural uses have little seasonal overlap, they have less seasonal variation than space heating applications.

Between 1979 and 1983, propane use for agricultural purposes varied little (30). Future propane use in the agricultural sector will likely remain constant. While its use will decline as the natural gas distribution system is extended, these losses will be made up by growth in areas where natural gas is unavailable (20, p.27).

Transportation Fuel

Propane is an excellent motor fuel. Net savings for using propane can range up to 30% of a vehicle's total fuel bill. Propane lowers engine maintenance costs, increases engine life, and produces low levels of noxious emissions. Propane performs well, operating indefinitely at idle speeds without fouling, and eliminating vapour-lock and fuel line freezing (Appendix A).

Propane is suitable for use in existing gasoline engines. However, to obtain maximum performance, some modifications to the engine are required and the gasoline tank must be replaced with one capable of holding liquefied propane under a pressure of 100-200 psi. Conversions can be easily done by a trained and licensed propane vehicle converter.

The cost of conversion is presently around $1,500 (16, p.11) and can usually be recovered with some ease. For example, Ontario has eliminated its 7% sales tax on all purchases of licenced vehicles (both new & used) converted to propane within 30 days of purchase. This can cover about $840 of the conversion cost of a $12,000 vehicle. In addition, propane sold in Ontario for transportation fuel has no road tax levied against it, and therefore the lower cost for propane would payback the remainder of the conversion cost over 33,825 km of driving (assuming 70 percent of the distance in urban areas and propane priced 18¢/litre less than gasoline in the Toronto area).

Conversion centres are registered by the Ministry of Consumer and Commercial Relations. Conversion centres can be found under PROPANE in the Yellow Pages.

Propane engines are suitable for all vehicles ranging up to 13,600 kg. (7, p.2). The ideal applications are fleets which operate on a stop-and-go basis and which have high fuel consumption. The fleet user can minimize propane distribution costs with conveniently located bulk storage and can maintain his fleet to take advantage of propane's efficiency, low emissions, and longer engine life benefits (1, p.2).

Prior to the 1980's there was minimal use of propane in carburation application, with use mainly limited to special vehicles such as fork lift trucks and skating rink cleaners (32, p.3). In 1980 in an effort to reduce dependence on imported petroleum products, the Ontario government started the Propane Fuel Demonstration Project. The objective of the program was to achieve maximum penetration of propane into the transportation fuel market. Working with selected commercial fleet operations, information on the performance of propane powered vehicles was collected and publicized throughout Ontario.

The Ontario Government's Propane Fuel Demonstration Project illustrates the benefits of propane use in the transportation fuel market.

In Ontario, at least 175 million litres of gasoline have been displaced by the more than 50,000 vehicles powered by propane.

The positive results of this demonstration project together with tax breaks, conversion grants, and rising fuel prices, have resulted in vehicle carburation becoming a major propane market. The number of propane powered vehicles in Ontario increased from 10,000 in 1981 to 31,000 in 1982, and to 50,000 by 1983 (16, 0,5). This represents one per cent of the total number of vehicles in Ontario; propane consumption for transportation displaced 175 million litres of gasoline, or 1.5 per cent of the total volume of gasoline consumed in Ontario (16, p.19).

As the use of propane as a motor fuel has expanded, it has become readily available. There are more than 1,200 propane fuelling stations and 400 conversion centres in Ontario. They are expected to increase in number as propane continues to grow in popularity. Propane stations are not as plentiful outside the province. The following booklet lists the locations of service stations which supply propane:

Where to Buy Propane in Ontario (Plus Canada-wide Supplement)

Available from:

Communication Services
Ministry of Energy
62 Wellesley St. W.
Toronto, Ontario
M7A 2B7

(416) 965-2459

The majority of Ontario's propane powered vehicles belong to commercial fleets. However, as of the end of 1983, propane has only penetrated approximately 10 per cent of the commercial automobile fleet and 15 per cent of the commercial light truck fleet (16, p.9). With these fleets expected to grow 25 per cent by the year 2000, there is still a large potential for growth in the propane market. The rate of additional vehicle conversion will likely be slower than in the past as most readily interested fleet operators have already converted to propane.

The number of private vehicles converting to propane will remain small because most personal vehicles have a lower annual mileage, while a high annual mileage is necessary to justify conversion (7, p.2). Private motorists are often discouraged by the inconvenience of converting to propane, the need for specialized vehicle maintenance, and the lack of service stations outside Ontario supplying propane (1, p.2).

Growth in propane use in the transportation sector is expected to continue in the future. Ontario's use of propane for transportation increased from 5.5 m^3/d in 1980 to 600 m^3/d in 1983 (16, p.3), and is projected to increase to 2740 m^3/d in 1990 (20, p.3).

Industrial

Propane is widely used as a fuel for fork lift trucks. The low emissions of carbon monoxide and hydrocarbons during propane combustion enable trucks to operate indoors without creating a health hazard. The principal competing fuel in this application is electricity. Electricity is generally more expensive than propane and electric fork lift trucks are not as powerful as their propane powered counterparts (20, p.23).

In the construction industry, propane is often used as a portable energy source. Other fuels are often not available on site and propane cylinders can be easily delivered for tasks such as drying concrete or plaster. Propane is also extensively used in soldering tools because its clean burning and portability characteristics mean that they can be safely used anywhere.

Propane is also used as fuel in crude oil refining. Ontario's refineries used about 3.7 percent of their propane production as fuel during 1980 (20, p.21). Gas fractionation plants also use some propane as fuel. In 1980, gas plants in Canada consumed one percent of the propane they produced (20, p.21). However, there is only one gas fractionation plant in Ontario so the provincial consumption for this purpose is minimal.

Petrochemical

The most significant application of propane in Ontario is its use as a feedstock in the chemical industry. Propane cracking produces ethylene and propylene, key ingredients in the production of many petrochemical products. In Ontario in 1983, use of propane as a feedstock consumed over 30 percent of the total volume of propane used in the province.

The use of propane as a substitute feedstock for crude oil will likely increase if propane remains competitively priced. While ethylene can be produced from either natural gas, propane, or crude oil based feedstocks, the incentive to produce it from propane is forecast to increase due to propane's lower price compared to alternative feedstocks.

Propane Distribution In Ontario

Propane markets have a pronounced seasonal variability, with winter demand tending to be three times greater than summer demand (32, p.6). A common solution to seasonal problems is the use of storage. Above ground storage, however, is very expensive, and propane distributors tend to carry very little inventory. They rely instead on the transportation system to deliver their propane as needed from points of production or underground storage. While some underground storage capacity is available in Sarnia (about 600 million litres (25, p.8.)), most NGL's are stored in extensive salt caverns in Alberta.

Propane is transported from Alberta in one of two ways. Some propane in northeastern Ontario is purchased from gas fractionation plants in Alberta and transported to Ontario by rail. Rail transport is expensive but offers great flexibility in quantities and timing of shipments, and thus is suitable for low use areas. Most propane delivered to Ontario is shipped in the form of natural gas liquids through the Interprovincial Pipeline system to gas fractionation facilities in Sarnia (20, p.53).

Once propane is separated, it is shipped to distributors and large customers within the province. Since NGL's are easiest to handle when in liquid form, they are kept under pressure as liquids and transported in large tanks. Rail shipment using 115,000 litre tank cars is generally used for distances over 400 km. Tank trucks each carrying about 45,000 litres are used for transportation over shorter distances (20, p.53).

There is a well-developed propane distribution network in Ontario. Bulk distribution centres cover most of the province. From these central depots, deliveries are made to retail customers. Tank trucks (bobtails) are used to refill storage tanks which are leased from the fuel delivery company and installed on customer's premises. Most propane is delivered in this way. Residential and commercial customers have tanks with capacities ranging up to 1500 L; Agricultural and industrial customers may have larger storage tanks (20, p.57).

Another option is for delivery trucks to drop off 30L cylinders filled with propane. Such deliveries are generally used for fork lift trucks, welding and construction uses. Smaller 15L cylinders are used in camping trailers and barbecues. Most frequently these cylinders are brought by the customer to a service station to be refilled.

If required, additional quantities of propane could be delivered to Ontario via Interprovincial Pipelines, number two line and via the Cochin Pipeline System (20, p.4). Within Ontario, the existing propane supply network can handle the initial increase in propane demand. However, some expansion of the supply system will likely be necessary in the future.

Pipelines are the lowest cost of transporting large quantities of propane (20, p.54). As the quantity of propane consumed in Ontario grows, facilities for pipeline shipments of propane may eventually be developed. Receiving facilities could be installed on existing petroleum products pipelines so that they could carry propane within the province. Such pipeline transportation is safe. Extensive experience with propane distribution in the United States indicates that pipelines are the safest mode of bulk propane shipment (20, p.62).

Propane Exports

Historically there has been more propane produced in Canada than the domestic market has been able to absorb. Surplus production has been exported; in 1983 about 51 per cent of Canada's propane was exported to Japan and the United States (Table 3.4). In the future this percentage is likely to decrease. While the United States will continue to require propane imports (11, p.111-13), increased propane consumption within Canada will result in lower volumes being available for export. There will also be increased competition in the export market particularly from O.P.E.C. countries, as they begin to recover NGL's from oil and gas. As these facilities come on stream, large new volumes of propane will create excess world supplies.

As world supplies of propane increase, propane prices may fall and the U.S. demand for Canadian propane will likely shrink. Exports of propane to the United States, especially from Ontario, have been decreasing over the past few years.

Table 3.4

Historical Propane Exports

(m^3/d)

Year	Ontario Exports	Canadian Exports	Percent of Canadian Exports from Ontario
1975	2,872	9,591	29.9
1976	3,993	10,923	36.6
1977	6,099	13,149	46.4
1978	4,690	9,680	48.5
1979	4,555	12,663	36.0
1980	3,650	11,137	32.8
1981	3,227	9,964	32.4
1982	3,742	11,079	33.8
1983	2,230*	9,740*	22.9

(Source: NEB, Product Disposition Summary Reports; *Statistics Canada, 75-003)

Ontario exports the surplus NGL's that it receives from Alberta. The volume of propane exported from Ontario is significant in that these supplies could be used within the province. If future propane consumption in Ontario grows over 40% (the volume of propane presently exported from the province), major changes might be required to transport additional volumes of propane to Ontario.

While this is not likely to happen in the near future, uncertainty about future export opportunities is fueling propane producers growing attention to domestic markets (32, p.5). Interest in domestic markets is also increasing due to government interest in energy self-sufficiency and the growing attraction of consumers to propane because of its low price.

Propane Safety

Safety is an important concern with the use of any combustible fuel. Propane is no exception. It is a flammable substance in both liquid and vapour states. Yet, when properly handled and used in conjunction with approved equipment, propane is no more dangerous than gasoline (33, p.4).

Virtually every aspect of propane transportation, storage, and distribution is regulated with respect to safety. While regulations cannot eliminate mishaps, they can reduce the incidence and severity of accidents.

In Ontario, propane is transported by truck and rail. Standards for Liquid Petroleum Gas (LPG) tank cars have been set higher than in the U.S. All transport units are inspected by provincial agencies to ensure compliance with a national standard established by the Canadian Gas Association. Accident rates are low: trucks average one severe accident per 14.7 million km travelled and rail cars average one per 19.2 million km (20, p.63).

Propane is stored in liquid form under pressure. All storage containers must be inspected by the Canadian Transport Commission to ensure that they meet manufacturing standards. Containers are tested at three times their working pressure and all containers and fuel lines have multiple safety valves (18, p.9). All other aspects of the retail distribution of propane are regulated by the Fuels Safety Branch of the Ontario Ministry of Consumer and Commercial Relations.

Because propane is stored and handled under pressure, it is always kept in a completely enclosed system and storage tanks are isolated from the loading/unloading area. This reduces the risk of fire or explosion in the event of an accident and eliminates the exposure to dangerous vapours that occurs with gasoline (18, p.9). The danger of explosion is minimized because, unlike a gasoline tank which contains both gasoline and air, a propane tank contains only propane. Propane will not burn unless it mixes with air. To safeguard against undetected propane leaks, methyl mercaptan is added to propane. Its strong "rotten cabbage" odour becomes very apparent at 1/50th the concentration of propane requiredfor ignition. If such a smell is detected, the customer should be cautioned against lighting a match or turning an electrical switch on or off. The area should be well ventilated and the source of the leak located.

Propane is handled more frequently by individuals at cylinder refilling and distributor outlets than at any other stage from producer to consumer. Ontario has stringent regulations designed to minimize the incidence and severity of spills. Facilities must have approved electrical installations, tanks, pumps, and non-combustible building materials (20, p.61). Refilling should only be done by trained personnel who have a P-3 filling certificate.

To maximize safety, all propane equipment must be approved for the specific purposes for which it is employed. Appliances should be approved for particular uses and carry one of the following labels on the rating plate:

- Canadian Gas Association (CGA)
- Canadian Standards Association (CSA)
- Underwriters Laboratories of Canada (ULC).

These testing agencies are recognized throughout Canada. All installations should be done by trained personnel certified with a S-6A Fitters Certificate and inspected by a S-6B propane inspector (both are registered with the Ministry of Consumer and Commercial Relations). Poor installations could result in poor performance, costly maintenance, and increased operating hazards (33, p.4). More information on safety standards and the installation of propane-burning appliances and equipment is available through:

The Canadian Gas Association
55 Scarsdale Road
Don Mills, Ontario
M3B 2R3

In November of 1984, the Ministry of Consumer and Commercial Relations, in cooperation with the Ministry of Transportation and Communications, introduced a new propane motor vehicle safety program. Beginning in May 1985, it will be illegal in Ontario to fuel or drive an Ontario-licensed propane vehicle not displaying a windshield sticker indicating its fuel system has been inspected and meets government safety standards. Vehicles may only be inspected by certified staff at stations licensed by MTC. Copies of the brochure **Propane Motor Vehicle Safety: What You Should Know** are available through:

Ministry of Consumer and Commercial Relations
Communications Branch
555 Yonge Street - 9th Floor
Toronto, Ontario
M7A 2H6

4. BUTANE

Butane Supply

Western Canadian natural gas processing plants provide 75 per cent of Canada's total butane production. Production from oil refineries accounts for the remaining 25 per cent of total butane supply. Ontario refineries produce about 30 per cent of Canada's refinery butane production (13, p.IV-2).

Historically, gas plant butane production has been relatively steady in a range of 10,000 to 11,000 m^3/d with refinery production averaging between 3,000 to 4,000 m^3/d (Table 4.1). Butane volumes from refineries have increased due to increased severity of refinery operations which have been developed due to increasingly favourable economics of extraction. The yield of butane from crude oil has steadily increased from 1.04 per cent in 1977 to 1.75 per cent in 1981 (13, p.IV-2). Ontario refineries led the increase in butane production as they increased volumes from 904 m^3/d in 1977 to 1,681 m^3/d in 1981 (22). Butane production from Alberta's gas plants is forecasted to sharply decrease in the 1990's, from present levels of over 10,000 m^3/d down to nearly 6,000 m^3/d in the late 1990's (13, p.11-6). This reduction is mainly the result of natural gas reserves becoming "leaner" (lower NGL content). Unlike natural gas based butane supplies, refinery butane production will remain stable with Ontario producing near 1,100 m^3/d (13, p.IV-11).

World markets are expected to have an increasing surplus supply of butane through to at least the 1990's (12, p.111-9). This surplus is expected due to the recovery of additional butanes associated with OPEC crude oil production (11, p.111-6).

Canadian butane supplies will exceed projected domestic requirements, thereby continuing the need to maintain and even expand export markets in a period of increasing competition for export markets (6, p.V1-8). Ontario will likely continue to have a butane surplus of approximately 10,410 m^3/d in 1985, 6,850 m^3/d in 1990, and 5,758 m^3/d in 1995 (20, p.50).

Table 4.1

Historical Butane Supply in Canada

(thousand m^3/d)

Supply	1979	1980	1981	1982	1983 (est).
Gas Plants	10.9	10.2	9.8	9.8	9.5
Refineries	1.9	2.3	2.9	2.5	2.6
TOTAL	12.8	12.5	12.7	12.3	12.1

(Source: NEB, CANADIAN ENERGY: Supply and Demand 1983-2005)

Butane Prices

As with propane, Canadian butane prices are directly affected by butane prices in the U.S. market (12, p.111-7). Canadian butane prices for both export and domestic markets are essentially the same. The forecast average annual growth rate for butane prices is 8.0 per cent per nyear well into the 1990's (11, p.111-7).

Since butane is primarily used for gasoline blending, its price tracks that of gasoline which in turn is related to the price of crude oil. On a liquid volume basis, butane is currently priced close to the price of crude oil (analysis of Ref. #11). This price ratio is expected to slowly drop if Middle East NGL production creates the predicted substantial world wide butane surplus (24, p.1).

Canada's Use of Butane

Historically, refinery uses have been the major consumer of butanes in Canada. Between 1979 and 1983, refinery uses accounted for over 60 per cent of the total volume of butane used in Canada (Table 4.2).

Some butane is not recovered and is left in the fuel stream to power refinery processes ("Processing" category). However, most butanes are used for blending motor and aviation gasoline.

Table 4.2

Historical Butane Demand in Canada

(m^3/d)

Demand	**1979**	**1980**	**1981**	**1982**	**1983**
Miscible Flood	1,022	960	966	928	875
Petrochemical	936	771	910	488	650
Gasoline Blending	3,275	3,591	3,707	3,281	3,450
Processing	1,824	1,690	1,895	1,672	1,263
All Other Uses	248	128	116	130	220
TOTAL	7,305	7,140	7,594	6,499	6,458

(Source: NEB, Product Disposition Summary Reports)

In the future, butane consumption for miscible flood is expected to increase to over to 2,120 m^3/d by 1990 as crude oil producers attempt to recover additional oil quantities from existing wells (26). Butane's use in the petrochemical industry is forecast to drop to 500 m^3/d by 1986 unless the price of butane is reduced to make it more competitive with alternative feedstocks (26).

Ontario's Use of Butane

Historically, most of Ontario's butane consumption has been for gasoline blending (Table 4.3). While consumption for this purpose may decrease, over 1,000 m^3/d of butane will likely continue to be used in Ontario for gasoline blending (26). All other butane uses are forecast to remain at low levels into the 1990's.

Table 4.3

Historical Butane Demand in Ontario

(m^3/d)

Demand	1979	1980	1981	1982	1983
Petrochemical	425	275	478	78	180
Gasoline Blending	690	930	1,234	1,094	960
Processing	399	182	271	275	208
All Other Uses	38	3	5	1	2
TOTAL	1,552	1,390	1,988	1,448	1,350

(Source: NEB, Product Disposition Summary Reports)

Refinery Use

Historically, gasoline blending has consumed large amounts of butane in Ontario.

Butane is added to gasoline because it has good anti-knock characteristics (high octane). Its use is limited by high volatility, which causes vapour pressure problems, particularly in warm weather. In the winter time, the volatility is helpful for improving engine starting. Butane is also used as a feedstock for a number of refinery processes which produce other high octane compounds.

The trend towards lead-free gasoline will have major effects on the use of butane and its compounds in gasoline. At present, lead compounds are added to gasoline blends to raise their octane levels. As regulations reduce the allowable level of lead in gasoline, refiners must find alternative methods of raising octane levels. Several of the alternative options involve butane:

1. Various refinery streams can be processed more severely to manufacture more high-octane components. Several of these processes, such as alkylation, use butane as a feedstock. Others, such as reforming, produce butane as a by-product.

2. Various additives can be used as substitutes for the lead compounds. Two additives under active consideration are Methyl Tertiary Butyl Ether (MTBE) and methanol. Butane is one of the feedstocks required to make MTBE. It is not currently manufactured in Canada, but the advent of stricter standards for lead content is causing some interest in building a plant in Ontario.

Methanol, presently produced in Canada, can be readily manufactured from abundant indigenous natural gas supplies.

Because methanol is quite volatile, its use limits the amount of straight butane which can be added to the gasoline without exceeding the vapour pressure standards. While increased use of methanol would result in decreased use of straight butane, use of products manufactured from butane may increase. Methanol cannot be added directly to gasoline without an additive called a co-solvent, which prevents separation of the methanol from the gasoline. A typical co-solvent is Tertiary Butyl Alcohol (TBA) which is also produced from butane.

Individual refiners will meet the challenge of lead phase-down in different ways, depending on the configuration of their oil refineries and their projections of demand for various petroleum products. The net effect is therefore difficult to determine, but will likely be a reduction in the refinery demand for butane.

Petrochemical Feedstock

Aside from refinery uses, most of the historical demand for butane has been as an alternative to naphtha and/or gas oil feedstocks used for olefin production in the Sarnia area (13, p.IV-6). However, the use of butane as a petrochemical feedstock in Ontario has fallen from a high of 1,050 m^3/d in 1977 to 180 m^3/d in 1983.

Unless butane prices are considerably lower than forecast, it will likely remain too expensive for extensive use as a petrochemical feedstock. With two of the petrochemical producers in Sarnia having the capacity to handle some butane, there will likely be some spot purchases of butane when its price is low. However, these purchases will not be frequent and butane requirements for ethylene production at Sarnia are expected to remain below 180 m^3/d in the future.

Transportation

At present, there is negligible use of butane as a transportation fuel. However, butane can be readily substituted for propane in the transportation sector, but only during warm weather. The large quantities of butane presently exported to the United States could be used in the Ontario transportation system. However, this is unlikely since butane tends to freeze more readily than propane in cold weather.

Butane Exports

Butane is primarily used in the United States in the manufacture of gasoline. While there is not a large import market for butanes in the U.S. markets, Canada supplies 80% of the butanes imported into the U.S. (26). In 1980, Canada exported 6,298 m^3/d of butane, or 44 per cent of total production. (Table 4.4).

The U.S. will continue to be short of butane at least into the late 1980's. Therefore, any Canadian butane surplusses can be expected to continue moving to U.S. markets (12, p.111-7). Surplus Canadian butane supplies available for export are expected to remain over 8,000 m^3/d into the late 1990's (6, p.V1.5).

Table 4.4

Historical Butane Exports

(m^3/d)

Year	Ontario Exports	Canada Exports	Per Cent of Canadian Exports from Ontario
1975	1,148	6,259	18.3
1976	2,012	7,419	27.1
1977	2,856	6,872	41.6
1978	2,687	6,058	44.3
1979	2,888	7,468	38.7
1980	2,466	6,298	39.1
1981	2,787	6,970	40.0
1982	3,623	7,826	46.3

(Source: NEB, Product Disposition Summary Reports)

5. PENTANES PLUS

Pentanes Plus Supply

Nearly all of Canada's pentanes plus supplies originate from Alberta. The known reserves of pentanes plus in Alberta are near 173 x $10^6 m^3$ (NEB Submissions). These resources are contained solely in natural gas supplies. Major gas plants currently account for about 65% of Alberta's pentanes plus production (27, p.12).

Penatanes plus production is partially constrained by natural gas demand since some pentanes plus are also derived from cycling gas facilities. In Alberta, several condensate reservoirs have been on a cycling mode of operation. Pentanes plus are stripped from natural gas to prevent them from condensing below ground and the gas is reinjected into the well in order to maintain reservoir pressure.

The ratio of pentanes-plus to marketable gas in established reserves has declined from 160 $m^3/10^6m^3$ in 1969 to near 90 $m^3/10^6m^3$ in 1983 and is expected to drop to 50 $m^3/10^6m^3$ by about 1993 (9, (1983), p.23). This decline is generally a result of declining production from the large cycling pools which have historically produced much of Alberta's pentanes-plus. After 1993 the ratio is expected to gradually increase to 59 $m^3/10^6m^3$ as natural gas production from shallow, dry pools will decrease and deferred reserves, many of which have high liquid content, are brought on-stream (9, (1983), p.23).

In the 1980's, penatanes plus supply has been near 15,000 m^3/d (Table 5.1). Most forecasts have penatanes plus production remaining fairly constant near this historic level until the 1990's and then gradually declining as increased gas production levels are offset by declining yield.

Table 5.1

Historical Pentanes Plus Supply in Canada

(m^3/d)

1979	1980	1981	1982	1983
18,760	16,570	15,910	15,580	14,500

(Source: 21, p.18)

In the future, additional pentanes plus supplies may be stripped from Venture gas and associated gas from Hibernia. However, production of pentanes plus from these sources is not expected to start until the late 1980's at the earliest. Due to these frontier gases being relatively "dry" (low NGL content), peak pentanes plus production from these sources is projected to be only 2,000 m^3/d (27, p.124).

Domestic Pentanes Plus Consumption

While pentanes plus supply is expected to remain constant in the future, all pentanes plus volumes are presently utilized and domestic demand is expected to increase. In Canada, pentanes plus are used as a heavy crude diluent, for various refinery and petrochemical uses, and to transport NGL mixes.

Heavy Crude/Bitumen Diluent

Pentanes plus are given high priority as a diluent. Heavy crude oil and bitumen reserves in Alberta require pentanes plus as a diluent. Diluent is required to decrease the specific gravity and reduce viscosity of heavy crudes to allow pipelining. Since the minimum pipeline specification for gravity is 21° API (arbitrary specific gravity scale), most Alberta heavy crude and bitumen supplies require diluent in concentrations ranging from 3 to 30% by volume.

Asphalt demand influences the volumes of heavy crude and bitumen required for processing. Future asphalt production will depend increasingly on bitumen and heavy crude oil supplies which require diluent in order to be processed or moved.

There should be sufficient pentanes plus through the 1980's to meet heavy oil diluent requirements. However, beyond this date limited supplies could result in heavy crude oil and bitumen production restrictions. It is highly unlikely that all pentanes plus would be diverted to the diluent market for logistic and economic reasons. Even if all pentanes plus are used as diluent, there is still a projected deficit by 1995 (6, p.V1-10). The availability of pentanes plus would limit pipeline movement of bitumen to approximately 19,000 m^3/d unless alternatives are found.

As pentanes plus supply becomes restricted, small field refineries could be built to upgrade bitumen and heavy crude to pipeline requirements, pipeline specifications could be reduced, or small volumes of other liquids could be upgraded for use as diluent. Naphtha, sometimes mixed with pentanes plus to form a diluent mix, will become increasingly available in the future as gasoline demand falls and as lead phase-out requirements decrease the use of light naphtha for gasoline blending (because of its low octane levels). Therefore, as the naphtha requirement for gasoline production decreases, increased volumes of naphtha could be used as a heavy crude/bitumen diluent. Straight conventional light crude or synthetic crude could also be used as a diluent.

Another option is to maximize the recycling of pentanes plus for re-use as diluent. Small quantities of heavy crudes are presently utilized within Alberta refineries for asphalt production. This allows the diluent to be recycled with only small amounts of pentanes plus being required to make-up losses. Heavy oil upgrading projects would effectively increase the diluent supply as diluent would be recycled back to the field and would not be required to move the product to market (23, p.64).

NGL Pipeline Use

Pentanes plus are mixed with propane and butane to form a light hydrocarbon stream known as NGL mix. The pentanes plus content in the NGL mix is used to control the vapour pressure to meet pipeline specifications. Segregated pentanes plus is also a preferred material to use as a buffer for pipeline shipments of mixed NGL streams. Buffer volumes represent about one-third of the pentanes plus used in transporting NGL mixes with the remainder being contained in the mix.

The use of pentanes plus for NGL transportation is expected to be discontinued by the early 1990's because of its priority use as heavy crude diluent. If pentanes plus are unavailable, other arrangements would then be necessary to transport propane and butane to Ontario. Other materials such as light crudes or refinery produced naphtha would likely be used and/or pipelines would be upgraded to withstand higher vapour pressure.

Petrochemical Feedstock

Discontinuing the use of pentanes plus in NGL transportation would affect Ontario's petrochemical industry. Currently most of the NGL buffer and pentanes plus contained in the NGL mix are separated from the lighter compon;ents in Sarnia to fill a portion of the petrochemical industries' feedstock requirements. End products include ethylene, propylene, benzene, butylenes, and butadiene.

Petrochemical use is limited to one plant at Sarnia and demand levels never rise above the existing facilities capacity for condensate. This demand for pentanes plus as a petrochemical feedstock will need to be filled from other sources if the expected shortage of pentanes plus develops. Petrochemical producers will likely be able to replace pentanes plus by using more butane and propane as feedstocks.

Refinery Uses

In Ontario refineries, when pentanes plus are used to produce petrochemical feedstocks, aromatics (high energy hydrocarbons) such as benzene, toluene, and xylene are recovered. These aromatics are excellent for use in producing high octane gasoline components, as well as being valuable petrochemical materials.

Incremental quantities of gasoline may be produced without using additional quantities of crude oil by processing pentanes plus. However, increased volumes of pentanes plus aggravate the product mix towards gasoline (for which demand is gradually decreasing). Therefore, although regulations to reduce lead levels in gasoline increase requirements for high octane gasoline components, refiners will not demand increased volumes of pentanes plus.

As available supplies of pentanes plus decrease, refiners will likely overcome this deficiency by higher processing of existing crude oil streams.

Pentanes Plus Exports

Unlike the other gas liquids, domestic demand accounts for most of Canada's pentanes plus volumes. Only small volumes of segregated pentanes plus are exported to the United States. These exports will continue in the short-term, but as demand in Canada increases, exports may be discouraged by pricing mechanisms or even prohibited by the National Energy Board (NEB) which sets export quotas.

While volumes of segregated pentanes plus sold to the United States have been decreasing, there is some concern that domestically needed pentanes plus may continue to move to the United States as diluent for heavy crude oil exports. This problem could be minimized by using naphtha or light crude as a diluent or recovering the pentanes plus in U.S. refineries and recycling it back to Canada for re-use as diluent for crude oil exports.

6. ETHANE

Ethane Supply

In the 1980's ethane production in Canada averaged near 12,000 m^3/d (Table 6.1). Ethane production varies according to the economics of gas-liquids extraction and total demand. Considerable flexibility exists in meeting ethane demand by adjusting recovery percentages at gas separation plants. When the demand for ethane is low and/or its selling price is low, extractors have the option of leaving ethane in the gas so that the ethane sells for the same price as the methane component (34, P.34).

Table 6.1

Historical Ethane Supply in Canada

(m^3/d)

1979	1980	1981	1982	1983
10,030	12,200	12,800	11,640	12,890

(Source: ERCB, Monthly Statistics Reports)

In addition to the economics of extraction and the demand for ethane, ethane production reflects changes in demand for natural gas. While little ethane is expected to be recovered from "dry" frontier natural gas, ethane supplies are expected to increase to near 24,000 m^3/d by 1990 as additional natural gas plants commence production in Alberta (19, p.35).

Domestic Ethane Consumption

Although propane, butanes, and pentanes plus have broad markets, at present segregated ethane has only one major use — as a chemical feedstock (Table 6.2). Ethane's past use in solvent flood and as gas plant fuel decreased and use of ethane for petrochemical uses increased.

Table 6.2

Historical Ethane Demand in Canada

(m^3/d)

Use	1978	1979	1980	1981	1982	1983
Petrochemical	18	1,944	3,769	5,154	3,318	4,975
Miscible Flood	1,151	953	334	—	—	600
Gas Plant Fuel	25	78	—	—	—	—
TOTAL	1,194	2,975	4,103	5,154	3,318	5,575

(Source: ERCB, Monthly Statistics Reports)

In the late 1970's, ethane began to be used in Alberta as a feedstock to manufacture ethylene. Ethane does not yield the broad range of co-products produced by naphtha, pentanes plus, and butane, the main alternative feedstocks. In western Canada, the petrochemical industry uses ethane extracted from natural gas as the feedstock to produce ethylene. This feedstock requires a relatively simple, low cost ethylene plant. Ethane is the preferred feedstock for ethylene production when large volumes of the co-product primary petrochemicals are not required.

With the planned start-up of the second unit at Alberta Gas Ethylene's plant in 1984, petrochemical requirements are expected to climb to near 7,500 m^3/d (6, p.VI-3). While originally only ethane recovered from gases released during refining processes were used in Ontario has a feedstock, in the early 1980's ethane was purchased for use in Ontario as a petrochemical feedstock. On a trial basis, ethane supplies of under 880 m^3/d are imported from the U.S. for use in ethylene production. If this operation, which has a base agreement through 1987, is profitable, ethane would likely continue to be used by some of Ontario's petrochemical producers. A second Ontario petrochemical producer is considering using ethane as a petrochemical feedstock beginning in late 1984/early 1985.

The use of ethane for miscible flood projects is forecast to increase sharply to over 9,000 m^3/d by 1986 (6, p.VI-3). This demand is then projected to decrease in the early 1990's as the use of carbon dioxide for enhancing oil recovery is developed.

Ethane Exports

In the past, ethane has usually been the preferred ethylene feedstock in the U.S. With minimal domestic requirements, approximately 60 per cent of Canada's ethane supplies have been exported to the United States (Table 6.3).

Table 6.3

Historical Ethane Exports

(m^3/d)

1978	1979	1980	1981	1982
2,228	6,691	7,989	7,758	8,149

(Source: ERCB, Monthly Statistics Reports)

Ethane will likely continue to be a major ethylene feedstock in the future and surplus Canadian supplies could be exported to the U.S. (34). However, as miscible flood and petrochemical demands for ethane in Canada peak in the late 1980's, surplus volumes will drop to below 1,000 m^3/d (6, p.VI-4).

In the 1990's as carbon dioxide begins to be used for enhanced oil recovery (EOR) schemes and as up to 50 per cent of the ethane injected for EOR schemes is recovered, volumes available for export will increase to near 10,000 m^3/d (6, p.VI-4).

7. CONCLUSION

Natural gas liquids are playing an increasingly important role in Ontario's energy picture. Pentanes plus appears to be the only NGL that is forecast to be in short supply. In the future, most of Canada's pentanes plus supplies will be used as diluent to enable heavy crude/bitumen supplies to be transported by pipeline. As a result, exports of segregated volumes of pentanes plus will likely be discontinued in the near future. The use of pentanes plus in the petrochemical industry, in NGL transportation, and its consumption for other purposes will likely decrease to insignificant amounts by 1990.

As pentanes plus use becomes concentrated in Alberta, volumes available for use in Ontario will decrease. In Ontario's refineries, aromatics have been recovered during the refining of pentanes plus. These hydrocarbons were used in producing high octane gasoline and were valuable petrochemical materials.

As available supplies of pentanes plus decrease, Ontario refiners will likely maintain levels of gasoline production by higher processing of existing crude oil streams. Several of these processes, such as alkylation, use butane as a feedstock while others, such as reforming, produced butane as a by-product.

In compliance with regulations to reduce levels of lead in gasoline, existing refinery streams can be more severely processed or various additives can be used as substitutes for the lead compounds. Butane is used in the production of several of these substitutes. However, only limited amounts of straight butane can be added to gasoline containing these additives in order to avoid exceeding vapour pressure standards. As a result, refinery demand for butane in Canada and Ontario is likely to remain near present levels.

Ontario's petrochemical industry will need to fill the demand for pentanes plus from other sources. Petrochemical producers will likely be able to replace pentanes plus by using more propane, butane, or crude oil based feedstocks. While some use of ethane is projected, its use in Ontario's petrochemical industry will be limited due to continued demand in Ontario for petrochemical co-products not available from ethane.

However, unless butane prices are considerably lower than forecast, butane will likely remain too expensive for extensive use as a petrochemical feedstock. Therefore, with butane use limited primarily to gasoline blending, butane consumption is projected to remain constant and butane exports are expected to continue to remain high as long as there is demand for it in U.S. markets.

The incentive to produce ethylene from propane will likely increase due to propane's lower price as compared to alternative feedstocks such as naphtha.

At the same time, growth in propane use in Canada's and Ontario's transportation sector is expected to increase (to over 1,000 m^3/d in Ontario and to near 1,600 m^3/d for all of Canada). The expected increase in Ontario's propane demand up to 1990 is approximately equal to the amount of propane now exported from the province.

For Canada as a whole, if production were to remain constant, expected propane demand could be met by reducing exports to 3,000 m^3/d. Much of this increased demand will be for propane use in miscible flood projects.

The use of ethane in miscible flood projects is also projected to sharply increase (to 9,000 m^3/d by 1986). Combined with increased use of ethane in the petrochemical industry, primarily in western provinces, even if all ethane exports were stopped, ethane production would have to increase. However, this does not appear to be a problem as there are large additional volumes of ethane that could be extracted from natural gas as demand increases.

In summary, as Ontario and the entire nation strive for greater independence from imported fuels, there will be increased reliance on indigenous fuel sources, such as natural gas liquids. With the exception of pentanes plus, it appears that NGL's will continue to be available to meet increased demand. If production levels remain near present levels and if exports are reduced to balance growing domestic demand, NGL supplies in Canada should last 50 years. The use of these liquids to displace crude oil is one important step in relieving dependence on foreign energy supplies.

8. GLOSSARY

Alkylation	In refineries, alkylation processes combine hydrocarbons to form valuable gasoline blending components of good ignition quality (high octane value). Most commonly, iso-butane is combined with an olefin.
Aromatics	Aromatic hydrocarbons contain carbons in a ring formation. They are very stable and are suitable for use in blending high octane gasoline.
Butane	A gaseous hydrocarbon that liquifies under moderate pressure. Butane, (C_4H_{10}), is found in two forms in both raw natural gas and crude oil. In the most common form, known as normal butane, the carbons are aligned in a straight chain. The second form, known as iso-butane, consists of a branched chain compound. Normal butane is often converted to iso-butane due to the high demand for iso-butane for use in gasoline blending and for petrochemical uses.
CO_2 Flooding	A tertiary recovery process in which carbon dioxide is injected into a crude oil reservoir in order to dilute the reservoir fluid.
Cycling Gas Pools	A natural gas pool into which part or all of the produced natural gas in reinjected after removal of natural gas liquids in a gas processing plant.
Condensate	A mixture composed mainly of pentanes and heavier hydrocarbons recovered as a liquid from gathering facilities before the gas is processed in a plant.
Crude Bitumen	A naturally occurring viscous mixture, mainly of hydrocarbons heavier than pentane, that may contain sulphur compounds, and that in its natural state is not recoverable at a commercial rate through a well.
Diluent	Natural Gas Liquids or any other substances which are injected into bitumen and/or heavy crude oil to reduce viscosity to allow for pipeline movements.
Enhanced Recovery	A general term for the incremental volume of crude oil and natural gas recoverables over the volume recoverable by natural depletion processes.
Ethane	A colorless, odorless, inflammable hydrocarbon present in natural gas. Its chemical composition is C_2H_6.
Feedstock	Raw material supplied to a refinery or petrochemical plant.
Petroleum Gas (LPG)	These gases consist primarily of the hydrocarbon compounds propane or butane, or a combination thereof.
Methane	A colourless, odorless, inflammable hydrocarbon which is the main constituent of natural gas. Its chemical composition is CH_4.
Middle Distillates	The range of refined petroleum products which includes kerosene, stove oil, diesel fuel, and light fuel oil.
Miscible Flooding	An enhanced recovery process in which fluid, capable of dissolving in the oil it contacts, is injected into a reservoir to form a single liquid that can move through the reservoir to a producing well more easily than the original crude oil.

Natural Gas Liquids (NGL)	Natural Gas Liquids are those hydrocarbon components recovered from Raw Natural Gas as liquids by processing through extraction plants or gathering facilities. These liquids include ethane, propane, butane, and pentanes plus, or a combination thereof.
Olefins	Olefins are gases which have one or more double bonds between carbon elements. Olefins are recovered during refinery and petrochemical processes during which hydrocarbon chains are split or "cracked" to form shorter compounds suitable for use in the production of motor gasoline. Olefins are primarily used as a feedstock for secondary petrochemical production as well as a feedstock for alkylation.
Pentanes Plus	A mixture mainly of pentanes (C_5H_{12}) and heavier hydrocarbons which ordinarily may contain some butanes. Pentanes plus are generally a by-product obtained from the production and processing of Raw Natural Gas or Condensate.
Propane	Propane is a light, colorless hydrocarbon which is found in both raw natural gas and crude oil. Propane's chemical composition is C_3H_8.
Reforming	In this process, a stream of light naphtha is heated in the presence of a catalyst and chemically re-formed into high octane gasoline blending stock.

9. REFERENCES

1. Anderson, B. (1983) "Propane Supply and Distribution, Dome Petroleum Ltd., Calgary, Alberta.
2. "Banking On Gas Liquids" (1984) *Financial Times*, Vol. 73, No. 4, July 16.
3. British Petroleum Co. Ltd. (1977) *Our Petroleum Industry* 5th ed. London, England.
4. "Canadian Oil Reserves Achieve Modest Gain" (1984) *Oilweek*, Vol. 35, No. 21, June 25.
5. Dept. Energy, Mines & Resources (1983) "Propane Prices in Ontario", Ottawa, Ontario.
6. Dome Petroleum Ltd. (1984). "Energy Update, Supply/Demand Forecasts, 1983-2005", Calgary Alberta.
7. Elliott, D. (1982) "An Overview of Propane As A Transportation Fuel", Ontario Ministry of Transportation and Communications, Toronto, Ontario.
8. Emco Wheaton Ltd. (1983), "Why Convert From Gasoline to Propane?", *Propane/Canada*, March-April.
9. Energy Resources Conservation Board (1983) "Alberta Oil Supply 1983-2007", NEB Submission, Calgary, Alberta.
10. Energy Resources Conservation Board (1979-1983) "Alberta Energy Resource Industries Monthly Statistics", Calgary, Alberta.
11. Foster Research (1984) "Petroleum Pricing Service, 1984-2004", Toronto, Ontario.
12. Foster Research (1983) "Petroleum Pricing Service, 1983-2004", Calgary, Alberta.
13. Foster Research (1982) "The Canadian Supply of and Canadian Demand for Propane and Butanes, 1977-2000", Calgary, Alberta.
14. Holder, C. (1980) "An Overview of Propane Carburetion Economics in Ontario", Dome Petroleum Ltd., Calgary, Alberta.
15. "Hydrocarbon Processing", *1980 Refining Process Handbook* (1980), Gulf Publishing Co., Houston, Texas.
16. IBI Group (1984) "Transportation Sector Consumption of Alternative Fuels", Toronto, Ontario.
17. Kent Marketing (1984) "Price Cluster Reports", March, St. Catharines, Ontario.
18. Larock, .J (1982) "The Potential for Propane", Address to the Corpus Energy Pricing Conference, Inn on the Park, Toronto, Ontario, October 7-8.
19. Liddle Engineering Ltd. (1984) "Comparison of NEB Supply Submissions", Toronto, Ontario.
20. Middleton Assoc. et. al. (1982) "Assessment of Propane Supply and Distribution in Ontario", Toronto, Ontario.
21. "Mid-Year Review and Forecast" (1984) *Oilweek*, July 23.
22. National Energy Board (1975-1982 incl) "Product Disposition Summary Report, Ottawa, Ontario.
23. Nova (1984) "Update of Energy Supply and Demand, 1983-2005", NEB Submission, Calgary, Alberta.
24. Ontario Ministry of Energy (1983) "Feedstocks and Petrochemical Pricing — An Analysis of Trends and Their Impact on Petrosar", Toronto, Ontario.
25. Ontario Ministry of Energy (1982) "Propane — A Multi-Purpose Energy Source, Toronto, Ontario.

26. Petranik, Hank (1984) "Propane in Canada — Presentation to The Ontario Ministry of Energy", Dome Petroleum Ltd., Calgary, Alberta. Updated for 1985 by Dome Petroleum, Marketing Division, Sarnia, Ontario.

27. Petro-Canada (1984) "Update of Energy Supply and Demand, 1983-2005", NEB Submission, Toronto, Ontario.

28. "Propane Safety and the Recreational Vehicle" (1982), *Propane/Canada,* March-April.

29. Schaus, David (1983) "Review/Forecast of LPG Industry Supply and Demand Trends", *Propane/Canada,* May-June.

30. Statistics Canada (1978-1983 incl) "Quarterly Report on Energy Supply-Demand in Canada", No. 57-003, Ottawa, Ontario.

31. Story, Neil (1980) "Propane As A Substitute Fuel In The Ontario Agricultural Sector", Crandall Energy Consultants Ltd., Toronto, Ontario.

32. Taylor, A. (1979) "Propane As A Motor Fuel", Propane Study Group, Toronto, Ontario.

33. Whitfield, W. (1982) Propane As A Transportation Fuel", PGAC Carburetion Committee, Toronto, Ontario.

34. Winton, John (1984) "The Looming LPG Glut", *Chemicalweek,* May 2.

35. Wood, Ronald (1982) "Propane Dries Grain Harvest", *Propane/Canada,* September-October.

APPENDIX A

Advantages of Propane as a Motor Fuel

Propane is an attractive alternative motor fuel for the following reasons:

1) **Efficiency:** Since propane is in a gaseous form (except at temperatures below —42°C), combustion is more complete and propane's energy conversion efficiency is from 10% to over 30% more efficient than gasoline, depending on the type of installation and use (14, p.1). Although it only contains 75% of the energy in gasoline, finely tuned, factory installed propane vehicles can obtain close to the same mileage as gasoline powered units (7, p.2).

2) **Fuel Savings:** Propane is cheaper than gasoline and removal of Ontario's Motor Fuel Tax on Propane has made it even more attractive. Even allowing for 20% lower mileage, net savings for using propane can still range up to 30% of a vehicle's total fuel bill. In general, the more you drive, the more attractive a propane conversion becomes.

3) **Maintenance:** Propane lowers engine maintenance costs and increases engine life, especially in urban driving. Propane burns cooler, leaner and has fewer additives than gasoline; hence it does not tend to corrode or leave lead, varnish, or carbon deposits to foul the engine (1, p.2). It is common to obtain at least double the engine and spark plug life and more time between oil changes when operating on propane (33, p.1). Engine life on propane should increase considerably.

4) **Emissions:** Propane's leaner fuel-air combustion mixture, and its more complete combustion, compared to gasoline, results in lower emissions of carbon monoxide, nitrous-oxide, hydrocarbons, and in a lack of sulphur emissions.

5) **Performance:** The better mixing and distribution of propane aids cold starting and operation (32, p.10). Even at —30°C propane vaporizes readily to provide a uniform fuel mixture to all cylinders without the need for chokes (8, p.31). As there is no air or water vapour in a propane tank, vapor-lock cannot occur in hot weather and the fuel line cannot freeze in cold weather (8, p.31). Propane can operate indefinitely at idle speeds without fouling. The high octane rating of propane (approximately 110) allows a higher compression ratio to be used, thus enabling power output to be increased without using more fuel (8, p.31).

6) **Safety:** Propane is possibly safer than gasoline because heavy steel tanks, automatic shut-off valves, and vapor pressure locks minimize the possibility of fuel leakage and fire occuring in event of an accident (20, p.67). Propane tanks, constructed to handle up to 5 times their normal working pressure, have over 20 times the rupture resistance of conventional gasoline or diesel tanks (25, p.14).

7) **Supply:** Canada has large reserves of propane. Self-reliance means that supply is secure and less likely to be interrupted.

8) **Security:** Fuel theft is unlikely as liquid propane cannot be transferred to another pressurized container with a special pump (7, p.2).

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ISBN 0-7729-0564-9
200/6-85/895